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AUTHOR(S):

MURUGAN, A.

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Sea turtle research in India: an overview with focus on identification of priority research areas

A. MURUGAN
Suganthi Devadason Marine Research Institute,
44-Beach Road, Tuticorin-628 001, Tamil Nadu, India
E-mail: muruganrsa@yahoo.co.in

ABSTRACT
India has a unique status of distribution of five species of sea turtles (olive ridley, green, hawksbill, leatherback and loggerhead) all along its coast line including the Andaman and Nicobar and Lakshadweep Islands. Olive ridley has attained a novel status for the annual mass nesting along Orissa coast. Naturally, most of the work has been focused towards this species. The work pertaining to sea turtles on other species is scarce. Much work has been on stranding and nesting on the beach. The sea turtle migration to the Indian coast line is on the decline owing to many factors including beach alteration and increased fishing pressure. However, the follow-up of the earlier work to identify the factors responsible for the decline and mitigation measures is lacking. Sea turtles need to be monitored on a long-term basis with much focus on their behavioural aspects. These are vital in order to understand their behaviour in the sea and to have an effective conservation and management system. Modern tools like PTTs and data loggers could be effectively employed to study the sea turtles. The research work on sea turtles along the Indian coast line has been reviewed in order to identify and suggest the priority areas.

KEYWORDS: sea turtles, India, conservation, research, priority areas

INTRODUCTION

India, with a coastline of about 7,516 kms, is endowed with rich biodiversity. The Indian coast is crowned with five species of sea turtles viz. olive ridley (*Lepidochelys olivacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta)* and leatherback (*Dermochelys coriacea*). Olive ridley is the most common and well known for 'arribadas' or annual mass nesting along Indian coast. Olive ridley, green, hawksbill and leatherback turtles have been reported to nest along the Indian coast. Loggerhead which has been reported along the Indian coast has not been found to nest. Orissa coast is unique for mass nesting of olive ridley turtles wherein three olive ridley mass nesting beaches-Gahirmatha, Devi river mouth and Rushikulya-are located. Tamil Nadu and Andhra Pradesh coasts are considered as the migratory pathways of olive ridleys for approaching mass nesting beaches in Orissa (Abraham, 1990; Tripathy and Choudhury, 2001). All the five species of sea turtles are listed under Schedule I of the Indian Wildlife (Protection) Act 1972 and India is a signatory to the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES).

The turtles migrating to Indian waters are on the decline. Increased fishing activity along the nesting beaches, incidental catch, beach developmental activities etc have resulted in a declining trend of sea turtles migrating to Indian waters. The incidental catches rank foremost among the detrimental factors. The incidental catch is more along Tamil Nadu coast next to Gahirmatha coast in Orissa and the gill nets account for the major killings (Rajagopalan et al., 2002).

In spite of the diversity of sea turtles distributed along the Indian coast, the studies pertaining to sea turtles are restricted to nesting site location, stranding, mortality etc. The biology, genetics, migration, feeding ground and the bahavioural studies are almost lacking or are very meager. This paper overviews the work that has been carried out and an attempt has been made to identify the areas which require priority research attention. It is to be noted that only published works or available reports have been taken into consideration for this overview.

STATUS IN ISLANDS

The Andaman and Nicobar Islands can be considered as the area which received more attention from the sea turtle point of view. Sea turtles constitute one of the important biodiversity resources of the Andaman and Nicobar Islands. Four species of sea turtles, (leatherback, hawksbill, green and olive ridley) occur along the Andaman and Nicobar archipelago, (Bhaskar and Rao, 1992; Andrews et al., 2001, 2002; Andrews and Tripathy, 2004; Andrews, 2003; Murugan, 2003) which consists of more than 300 islands with a coastline of about 1,962 kms. In the Andamans, 94 islands

have been notified as sanctuaries which include 30 islands as confirmed sea turtle nesting sites (Bhaskar, 1993).

Though mention of sea turtles was found in historical citations since 1800s (Mackey, 1847; Blyth, 1863; Man, 1883; Portman, 1899; Kloss, 1902; Alcock, 1902), the status of sea turtles in these islands lacks detailed information. The survey was initiated by Bhaskar in 1978 and is considered the first step in assessing in detail the sea turtle status in these islands (Andrews et al., 2006). Bhaskar (1979,a,b; 1980; 1981a,b; 1984a,b,c; 1993, 1994,1995,1996; Bhaskar and Whitaker, 1983; Baskar and Rao, 1992; Bhaskar and Tiwari, 1992; Bhaskar and Andrews, 1993) has given an account of sea turtles of the Andaman and Nicobar Islands and is a pioneer on sea turtle study in Andaman and Nicobar Islands. Andrews et al. (2001) have studied the status and distribution of marine turtles around the Andaman and Nicobar Archipelago.

Andrews and Tripathy (2004) have given a detailed account on the turtle nesting sites in the Andaman and Nicobar Islands. A lot of studies have been carried out on nesting of turtles in the Andaman and Nicobar Islands (Bhaskar, 1993, 1979, 1993; Andrews et al., 2001; Andrews and Shanker, 2002; Andrews and Tripathy, 2004; Andrews et al., 2006). Murugan (2005) has given a comprehensive compilation of turtle nesting areas in the Andaman and Nicobar Islands. Murugan (2007) has reviewed the research on sea turtles in the Andaman and Nicobar Islands and highlighted the needs that are to be addressed.

Loggerhead turtles were reported to occur in the Andaman and Nicobar Islands (Smith, 1941; Whitaker 1978; Khan 1983; Pande et. al., 1991). However, nesting of this species has not been documented both in the Andaman and Nicobar Islands, and the main land. Andrews et al. (2006) gave the opinion that this could probably be due to confusion between loggerhead and olive ridleys.

Andrews and Shanker (2002) reported that hawksbill population in the Andaman and Nicobar Islands is the largest in India and that of leatherback in Nicobar is one among the four colonies with more than 1000 individuals in Indo-Pacific. The hawksbill turtles are also considered as an important population in the northern Indian Ocean area (Andrews and Tripathy, 2004). Great Nicobar Island is unique in that all four species occur along its southeast coast (Sivakumar, 2002). Most of the leatherback rookeries in the Nicobars were found only in the early 1990s (Bhaskar and Tiwari, 1992; Bhaskar, 1993).

Regarding the feeding grounds of sea turtles, Bhaskar (1993) and Andrews et al. (2001) reported the extensive feeding grounds for *E. imbricata* and *C. mydas*. Coral reef and sea grass meadows are unique in the Andaman and Nicobar group of islands. The sea grass meadows are small in extent and are discontinuously distributed (Das, 1996). Nine species of sea grass out of 14 reported in the Coramandal coast were recorded in the Andaman and Nicobar Islands (Das, 1996). Also, the islands are rich in seaweed species and 55 seaweed species have been recorded in the Andaman and Nicobar islands (Gopinathan and Panigrahy, 1983). The green turtle is the most common species in the Andaman and Nicobar Islands, which nests almost year around (Sivakumar, 2002).

Sea turtles from other locations are known to visit the Andaman and Nicobar Islands. The leatherbacks tagged in Australia have been observed in Galathea beach on the southeast coast of Great Nicobar Island (Andrews, 2000).

The studies in Lackadweep Islands are scanty and limited to identification of nesting turtles.

STATUS IN MAINLAND COAST

Along the east coast, Orissa and Tamil Nadu have received more attention. In West Bengal State, three species of turtles (olive ridley, hawksbill and green) occur and illegal turtle meat trade has been reported in Raidighi, Kakdip and Namkhana in Sundarban area and in Gharichak, Thakurchak, Botipur and Ramnagar in Digha-Sankarpur area (Roychowdhury, 2001). In Orissa State coast, four species of sea turtles, (olive ridley, hawksbill, green and leatherback) have been reported. Gahirmatha is the largest rookery for olive ridleys in the world and is a part of Bhitarkanika Wildlife Sanctuary. Normally over 100,000 nesting turtles have been reported every year which sometimes rise to 600,000 nesting turtles (Karthik Ram, 2000). The incidental catch due to trawl and gill netting, habitat degradation due to *Casurina* plantation and artificial illumination at Rushikulya and Gahirmatha coasts are the detrimental factors (Kar, 2001).

In the Gulf of Mannar and Palk Bay on the south, except for the leatherback, the other four species were reported (Kar and Satish Bhaskar, 1982). In the Kanyakumari to Trichendur stretch, the core nesting area in 1960s and 1970s has been identified as between Manapad and Periathalai (Bastian Fernando, 1983).

An estimated 3000 to 4000 green turtles were landed annually between Rameswaram and Mimisal during 1960s and 1970s and green turtle represented three fourth of the catch (Rajagobalan, 1984). Special types of nets, 'Pachuvalai' and 'Kattuvalai' were used for turtle fishing and the green turtle constituted the major share of around 89% along Gulf of Mannar and Palk Bay

(Agatheesapillai and Thiyagarajan, 1979). Turtle poisoning related death or injury has been reported along the Tuticorin coast (Silas and Bastian Fernando, 1984). The turtle blood which is considered as an elixir (Rajagopalan, 1984) is consumed raw.

A survey in 1977 mentioned about turtle nesting in Puluvinichalli, Nallathani, Anaipar, Valiamunai, Appa, Valai, Mulli, Hare, Manoli, Manoli-Putti and Pullivasal Islands (CMFRI, 1977). However, the continuous poaching for eggs and meat trade have reduced the nesting intensity and only sporadic nesting is observed (Bhupathy and Saravanan, 2002). A recent study by Bhupathy and Saravanan (2003) indicated the poaching of 69 out of 72 nests by humans. Murugan and Naganthan (2006) reported the rescue of green sea turtles from the Gulf of Mannar. The stranding of 18 turtles (belonging to green, hawksbill and olive ridley) along the Gulf of Mannar in August 2007 (Murugan, 2009) is an indication of the sufferings they have to undergo due to increased fishing pressure. After many decades, a non-governmental organization People's Action for Development (PAD) has reported an incidence of nesting by olive ridley in February 2008 in Keezhavaippar village along the Gulf of Mannar coast (Murugan, 2009). The work related to sea turtles from other coasts are mostly related to stranding, nesting species etc.

OVERVIEW OF THE WORKS AND THE PRIORITY AREAS

After a review of the studies pertaining to sea turtles in India, the publications have been broadly grouped into 14 categories. They are 1) Distribution, Status, Survey, Observation; 2) Biology, Physiology, Growth rate, Food & Feeding, Commensals, Population dynamics; 3) Population Genetics; 4) Nesting activity, Habitat degradation; 5) Reproductive Biology, Eggs/Juveniles, hatching/hatchlings, Captive rearing, Arribadas/mass nesting; 6) Feeding ground; 7) Migration, tracking, tagging; 8) Stranding, landings, massacre; 9) Incidental catch, TED, mortality; 10) Threats, Conservation, Management; 11) Behavioural studies; 12) General; 13) Review and 14) Poisoning, meat trade, poaching, exploitation (Table 1).

The category 'distribution, status, survey, observation' was the most concentrated with 31% followed by conservation, management (20 %), general (12.8 %) and reproductive biology, breeding, eggs, hatchery, hatchling, captive rearing (10.8 %). The least concentrated were genetics (0 %), foraging ground (0 %), behavioural studies (0.49 %), biology, physiology, population dynamics (3.19%) and migration, tracking (2.46 %). The behavioural studies were pertaining to the breeding and behaviour of leatherback and olive ridley in Andaman and Nicobar Islands.

The sea turtle works were related to six categories viz. General, Olive ridley, Green, Hawksbill, Leatherback and Loggerhead (Table 2). The most related were pertaining to general studies with a contribution of 57.4% followed by olive ridley (35.6 %) and leatherback (3.56 %). Olive ridleys were much concentrated as they are abundant along east coast of India.

Table 1: Number and percentage of publications grouped into different maritime state-wise categories

Categories	Maritime states										Total	%
	WB	O	AP	TN	Ke	Ka	M&G	G	A&N	L		
Distribution, status, survey, observation	10	15	15	17	6	4	8	11	28	13	127	31
Biology, physiology, population dynamics	2	7	0	3	0	0	0	0	1	0	13	3.19
Genetics	0	0	0	0	0	0	0	0	0	0	0	0
Nesting activity, habitat degradation	0	4	2	3	2	0	2	0	7	0	20	4.91
Reproductive biology, breeding, eggs, hatchery, hatchling, captive rearing	4	22	1	13	1	1	0	2	0	0	44	10.8
Foraging ground	0	0	0	0	0	0	0	0	0	0	0	0

Migration, tracking	2	6	0	1	0	0	0	1	0	0	10	2.46
Stranding, landings	2	3	1	9	0	0	5	1	0	1	22	5.41
Threat, incidental catch, TED	2	13	5	1	1	0	0	0	0	0	22	5.35
Conservation, management	5	31	9	17	9	4	1	3	3	1	83	20
Behavioural studies	0	0	0	0	0	0	0	0	2	0	2	0.49
General	1	11	3	8	1	0	3	5	11	9	52	12.8
Review	0	1	0	1	0	0	0	0	0	0	2	0.49
Poisoning, meat trade, poaching, Exploitation	0	2	0	6	3	0	0	1	0	1	13	3.19
Awareness	0	0	0	0	0	0	1	0	0	0	1	0.25
Total	28	115	36	79	23	9	20	24	52	25	411	
%	6.8	28	8.8	19.2	5.6	2.2	4.9	5.8	12.7	6.1		

(WB-West Bengal; O-Orissa; AP-Andhra Pradesh; TN-Tamil Nadu; Ke-Kerala; Ka-Karnataka; M&G-Maharashtra and Goa; G-Gujarat; A&N-Andaman & Nicobar; L-Lakshadweep)

The sources of publications related to sea turtles were also grouped under 11 categories. They are 1) Reports; 2) Newsletter/Bulletin; 3) Journals; 4) Proceedings; 5) Ph.D. Thesis; 6) M.Sc. Thesis; 7) In books; 8) Books; 9) Newspaper Reports; 10) Others and 11) No citation (Table 3). The Newsletters/Bulletins formed the major source of publications with 49.8 % followed by unpublished reports (16.4 %) and Journals (10.2 %). Regarding geographical locations, publications related to Orissa were higher (31.4 %) followed by Tamil Nadu (17%), Andaman and Nicobar Islands (11.6%) and Andhra Pradesh (9%). The Andaman and Nicobar Islands can be considered as the area which received more attention from the sea turtle point of view. However, the status of sea turtles in these islands lacks detailed information, though found in historical citations since 1800s. Along the east coast, Orissa and Tamil Nadu have received more attention.

Table 2: Maritime-wise profile of studies related to sea turtles

Category	WB	O	AP	TN	Ke	Ka	M&G	G	A&N	L	Total	%
General	11	36	23	43	17	7	15	23	45	24	244	57.4
Olive ridley	17	96	13	20	0	0	4	0	0	0	150	35.6
Green	0	0	1	4	1	0	0	2	0	1	9	2.11
Hawksbill	0	0	0	3	0	0	1	0	1	0	5	1.19
Leatherback	0	0	1	4	5	0	0	0	5	0	15	3.56
Loggerhead	3	0	0	0	0	0	0	0	0	0	3	0.71
Total	31	132	38	74	23	7	20	25	51	25	426	
%	7.4	31.4	9	17.4	5.46	1.66	4.75	5.94	12	5.9		

(WB-West Bengal; O-Orissa; AP-Andhra Pradesh; TN-Tamil Nadu; Ke-Kerala; Ka-Karnataka; M&G-Maharashtra and Goa; G-Gujarat; A&N-Andaman & Nicobar; L-Lakshadweep)

Table 3: Profile of sources of publications related to sea turtle in India

	WB	O	AP	TN	Ke	Ka	M&G	G	A&N	L	Total	%
Reports	2	12	8	14	3	1	3	7	14	5	69	16.4
Newsletter/Bulletin	14	69	18	37	12	2	14	8	23	14	212	49.8
Journals	8	16	1	6	4	1	0	2	3	2	43	10.2
Proceedings	2	11	5	6	1	1	1	3	2	1	33	7.8
Ph.D. Thesis	0	0	1	1	0	0	0	0	0	0	2	0.48
M.Sc. Thesis	0	0	0	0	0	0	0	0	1	0	1	0.24
In books	4	11	0	3	2	2	0	2	3	1	28	6.65
Books	0	1	1	1	0	0	1	0	0	1	5	1.19
Newspaper Reports	1	3	0	2	0	0	0	0	2	0	8	1.9
Others	0	4	0	0	0	0	1	0	1	1	7	1.66
No citation	0	5	4	3	1	0	0	3	2	0	18	4.28
Total	31	132	38	74	23	7	20	25	51	25	426	
%	7.36	31.4	9	17	5.46	1.66	4.75	5.9	12	5.9		

(WB-West Bengal; O-Orissa; AP-Andhra Pradesh; TN-Tamil Nadu; Ke-Kerala; Ka-Karnataka; M&G-Maharashtra and Goa; G-Gujarat; A&N-Andaman & Nicobar; L-Lakshadweep)

The survey of literature indicated the following drawbacks.

- Most of the studies carried out are one time reports or for one season (especially during nesting activity) – as evidence by publication as reports in Bulletins/Newsletters
- Feeding grounds – no interrelated work pertaining to turtles – mostly predicted with availability of sea grass, corals, seaweeds etc.
- No continuous monitoring
- No detailed study on migratory pattern
- Lack of coordination among various agencies – for example, Casurina plantation carried out along Orissa coast as bioshield against natural calamities
- No detailed study except a very few instances

Based on the review of works that have been carried out so far, the flowing priority areas have been identified.

- Long-term and continuous monitoring
- Migration – satellite transmitters
- Genetic studies – population structure
- Foraging grounds – focused and dedicated study on sea turtle foraging grounds to understand and plan conservative measures
- Behavioural studies – to understand their nature in offshore waters
- Awareness creation and involving stakeholders in conservation activities

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